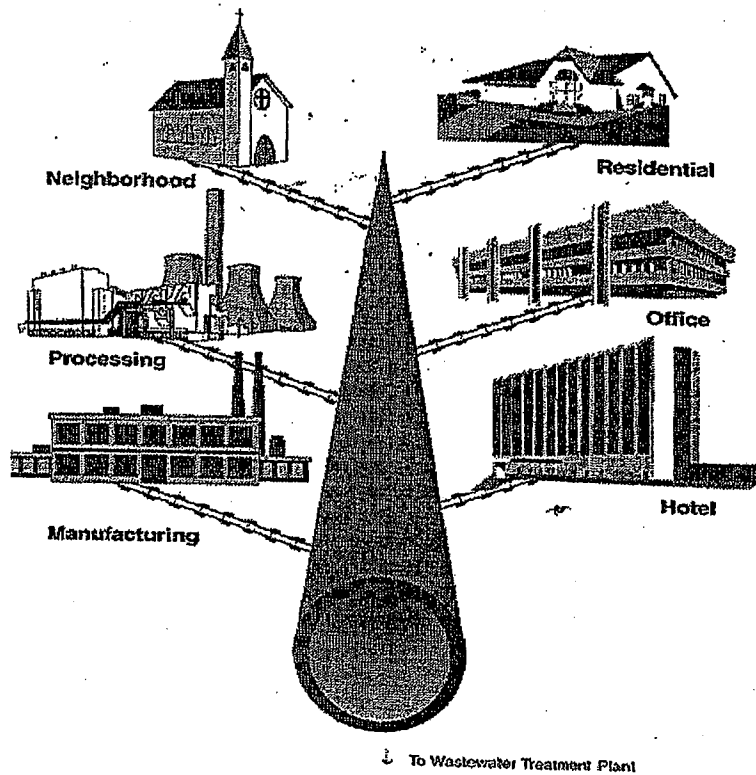



City of Houston

PUBLIC WORKS & ENGINEERING



THE WASTEWATER COLLECTION SYSTEM

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What does it take to provide citizens with the conveniences of a wastewater collection system?

Using the restroom, taking a shower, cleaning the dishes, and even washing your hands, these are all conveniences that citizens take for granted every single day. If you have ever flushed anything down the commode, let the dirt and grime run down the drain after a nice long bath, or disposed of food in the sink while cooking, you have taken pleasure in the use of a wastewater collection system. More than likely, you have never taken the time to think about where your waste goes or how it gets there, but you should not feel guilty about ignoring those things. The City of Houston's wastewater collection system is designed so people can do exactly that: dispose of unwanted waste without touching it, smelling it, cleaning it, or worrying about it once it disappears into that not-so-never-ending black hole. Although it is nice to enjoy these rewards, it also would not hurt to think about what it takes to provide citizens with the conveniences of a wastewater collection system. While citizens bask in their worry-free state, the City must take on the burden of collection and installation processes, reoccurring problems and necessary repairs, and preventive maintenance procedures in accordance with city and state standards in order to keep the wastewater collection system operating.

Basic Collection Process

For starters, it would be beneficial to obtain an overall picture of the collection process in order to further understand the aspects of installation and other procedures. Whenever you use the commode, shower, bathroom sink, or kitchen sink, you are using a source of wastewater. Small pipelines connect each source individually to one pipeline called the service line, which runs underneath the house. These small pipelines use water to help flush any solid waste smoothly down to the service line; hence the term wastewater. The service line is usually four to six inches in diameter, but it can be larger to accommodate a business or other larger buildings.

One important note is that the service line extends to the connection, which is the pipe segment that separates private property from city property. Everything from the initial sources of wastewater, such as the sink or commode, up to the connection belongs to the private side and is the responsibility of the home or business owner to have installed. The City's burden of installation, repair, or maintenance begins at the end of the service line. The service line is tapped into a larger pipeline called the lateral line, which runs along the length of the street

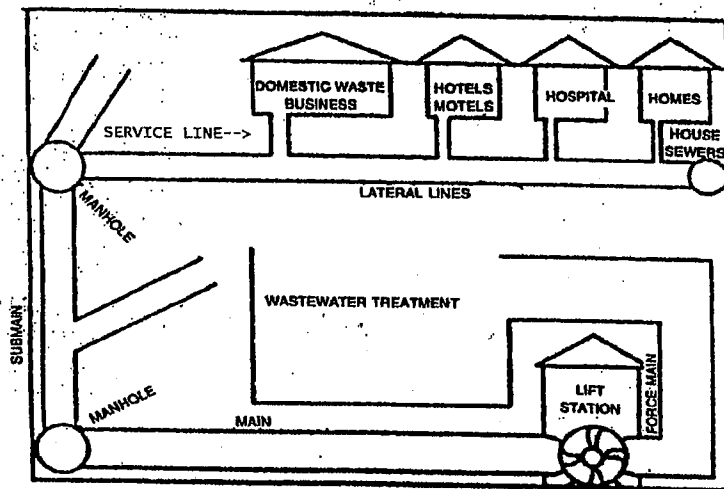


Figure 1: Collection System Layout

between the front of houses or in the back between the backyards of houses. The lateral is usually six to twelve inches in diameter depending on what area it is servicing and attaches the connections from each household

allowing the wastewater to combine into one line. Once the wastewater from each house flows down into the lateral, another, even larger, pipeline called the sub main will run perpendicular to the streets and will collect all the wastewater from each street combining them into one line much like the lateral line did for each house. The sub main is usually eight to fifteen inches in diameter and will eventually lead into a lift station. From the lift station, wastewater will travel into a twenty-four inch, or above, main called the outfall main or trunk line. The outfall main carries the wastewater straight into the wastewater treatment plant where employees can filter out solids, destroy pathogens, and abolish any other waste particles so that the water is safe enough to put back into households.

Installation Process

Now that the basics of the wastewater collection system have been set, one can better understand some of the installation processes required for the system to run properly. Before any work can be done, we must not forget that engineers must first plan and design the collection system. Engineers must design a wastewater collection system that can provide a minimum structural life of fifty years and also compensate for population growth up to twenty-five years in the future (Unit III). Once the design and plan process is complete, we can then consider some of the components installed on the collection system such as cleanouts, manholes, lift stations, and of course collection pipelines. Prior to installing any of these components, the ground must

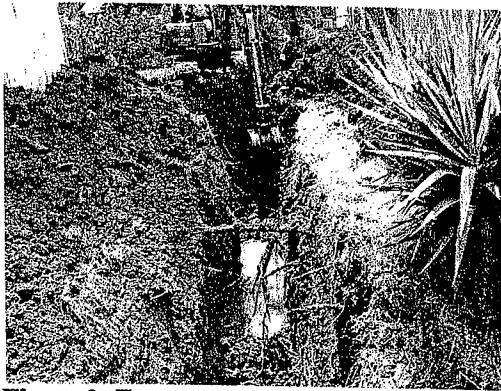


Figure 2: Excavator

be excavated accordingly using the appropriate tools and equipment such as the backhoe, a tractor like excavator that has a shovel bucket used to dig into the earth, and the pavement breaker, whose sole purpose is to plow through streets and sidewalks.

The flow of wastewater toward the treatment plant depends mostly on gravity, and this is why trenches excavated for pipes must always descend in elevation from the source to the lift station. Once the trenches are excavated correctly according to design standards, proper bedding is installed before laying down the collection pipelines. Proper bedding materials may include sand, white rock, and pea gravel. This practice

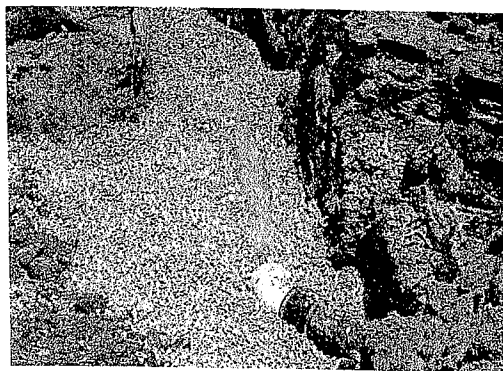


Figure 3: Bedding for Collection Line

prevents collection pipelines from moving around and also from settling deeper into the earth over time. High traffic areas, runoff water, and natural subsidence can all induce settling. After collection lines are set up, cleanouts are installed to allow

workers access to collection lines for preventive maintenance and clearing stoppages. Cleanouts look like short pipe segments, but they also have a third leg, called a stack, which elevates above the ground for two purposes. One reason is so that workers have access to the collection lines and another is so that in the case of a stoppage, wastewater floods out through the stack and into the homeowner's yard instead of into the house itself. Cleanouts come in both a "Y" shape and a "T" shape. The "Y" shaped cleanout is used on the connection so that water can only be shot

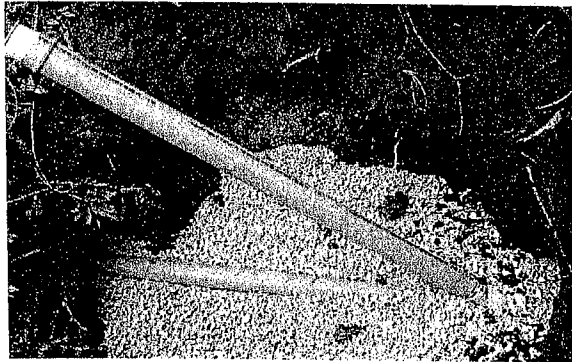


Figure 4: Y-Shaped Cleanout



Figure 5: T-Shaped Cleanout

out toward the lateral and not back into the customer's home causing more damage. The "T" shaped cleanout is installed only on the laterals so that water can be shot either way in order to break stoppages on both sides of the "T". Manholes are placed at collection line intersections and wherever there is a change in alignment, diameter, grade, or direction in the collection



Figure 6: Manhole

lines (Unit I). This allows workers access to the collection system for the purpose of cleaning or maintaining a collection line. Most often, workers will check to see if wastewater is backed up and filling the manhole indicating that the collection line is stopped up. Before the main reaches the treatment

plant, lift stations are installed to transport wastewater from a lower elevation to a higher elevation. Lift stations consist of a wet well, used to collect the wastewater into one place, and a

dry well, which houses the pump and motor. The pump and motor pull wastewater from the wet well and transport it to the higher elevation needed (Unit III).

Installation Setbacks

All of these components are necessary in some way to keep the wastewater collection system operating smoothly, yet there are always improvements to the installation and collection process that could possibly save the city a certain percentage of their budget every year.

Although city training for new employees is meticulous and well drawn-out, there will always be small differences between the textbook expectations learned through employee training and the actual procedures used out on the field. To many field workers, it may be challenging to abide by every single policy laid out in the handbook while also being expected to finish a certain number of jobs a day and make their labor hours as productive as possible. With the assistance of field supervisors and inspectors, the City limits spending more labor hours, more materials, and more equipment repairing installations that were not up to City standards. Despite these minor setbacks, the City still consistently employs new installations to the wastewater collection system while monitoring time and budget concerns.

General Collection Problems

Even though the collection and installation processes may have been intense and exhausting, the City's work is only just beginning. Once the wastewater collection system is set up and running, the City must then tend to reoccurring problems with the collection system and implement the necessary repairs. After decades of service and repair on the wastewater collection system in Houston, the City has established that the most frequent problems with the collection system are due to deteriorating pipelines, tree roots, grease, and the introduction of harmful chemicals into the system. The number one problem that the City must deal with on the wastewater collection system is deteriorating pipelines. In older days, the majority of pipelines

used in the wastewater collection system were made of concrete or ductile iron. Concrete pipes usually develop cracks over time and are easily corroded by hydrogen sulfide running through the system (Unit III). Ductile iron is heavy, expensive, and conducts electricity (Unit III). For these reasons, plastic pipes, also known as PVC pipes, made of polyvinyl chloride are now used to replace old concrete and iron pipes which have developed cracks over time. PVC piping is lightweight, easy for workers to handle, does not corrode, and has a smooth interior wall for less flow resistance (Unit III). No matter what piping material is used, tree roots still manage to produce a number of problems for the collection system because they slowly, but surely, work their way into connection seams and joints causing stoppages. Tree roots also generate cracks in pipelines, especially in older concrete ones, while forcing their way further across the underground. In spite of tree root damages, the major cause of collection pipeline stoppages is attributed to grease buildup. Grease, usually from restaurant areas, causes a large number of

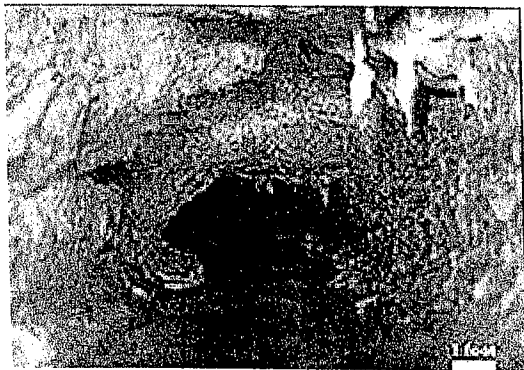


Figure 7: Grease Buildup

clogs in the collection system because of its thick consistency and ability to accumulate and form into large chunk-like forms. Another problem factor, not as obvious as grease, is the slow introduction of harmful chemicals into the collection system. When people introduce

harmful chemicals into the collection lines, they are contributing to the corrosion of the pipelines. Harmful chemicals, such as hydrogen sulfate and methane, slowly break down piping materials making them more fragile and susceptible to damage over time. These reoccurring problems each produce their own specific hazards to the collection system but most contribute to the gradual breakdown of pipelines. These deteriorated collection lines must then be repaired or, most likely, replaced.

Necessary Repair Procedures

When any of these common problems are reported to the City, there are unique procedures used to effectively resolve the situation. In the instance that a clog or stoppage is reported on the collection system, a stoppage team must first find the location of the clog and determine if it is the City's responsibility or the homeowner's responsibility. To do this, the team will first check manholes or cleanouts to see if they are stopped up. When a manhole contains an excessive amount of wastewater, stoppage teams know that there is a clog in the collection system. The stoppage team will then locate the manhole further downstream that does not have a surcharge of wastewater and use hydraulic jet washer hoses to shoot upstream and clear the clog. If there are persistent stoppages on a certain segment of the collection system, the City may televise that pipe segment. Employees will first clean the pipe segment, which is usually three to five hundred feet in length, and then pull a camera through the pipe so they can view the interior on a separate television screen(Unit III). This practice affectively locates cracks, open joints, grease, and tree roots that may be difficult to locate using other methods. If tree roots or serious grease back ups cause the stoppage, field workers will then have to excavate the area and gain entry to the collection line to manually remove the obstruction. Sometimes stoppages, cracks, leaks, or open joints on the collection system lead to excursions. When

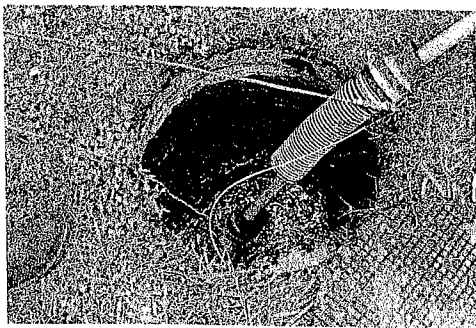


Figure 8: Manhole Jet-Washing

wastewater leaves its confinement, it is considered to be an excursion. Whenever there are cracks, leaks, or open joints on the collection system, repair teams are routed to make repairs on the damaged pipe segment. Repairs consist of removing deteriorated or damaged pipe

segments, which cause clogs and stoppages, and replacing them with new PVC pipe segments.

After learning the details of everyday repair processes, one can see that there are numerous

considerations taken into account in order to guarantee an operating status of the wastewater collection system.

Utilizing Repair Resources

With a non-stop number of repairs going on everyday, the City must record the costs of every repair and make certain that these repairs are being completed with minimal expenses. With the completely organized system of 3-1-1, dispatchers, investigators, field supervisors, field workers, and inspectors, the City of Houston makes this task look easier than it seems. Dispatchers, investigators, and field supervisors work together to make sure that maintenance teams are sticking to a tight schedule and that emergency repairs are being done right away so as to avoid immediate property damage. The City also maintains an abundance of high quality materials, equipment, and tools so that workers are as highly effective as possible. Despite the City's organized maintenance team and top-grade equipment, repair processes are still not perfect. It seems that increased interaction between field workers and field supervisors can help prevent miscommunications that lead to unnecessary excavations and the waste of labor, time, and materials. One responsibility of the stoppage team is to mark excavating areas for repair teams. In some instances, the stoppage team may miss-mark the area inducing excavations that are not needed. Another dilemma the City must deal with is the never-ending battle between private property and city property. The City's obligation is to continuously decide whether certain procedures are the responsibility of the City or the private owner. Any mistake made when deciding this usually leads to the misuse of city workers and materials. Once this happens, more of the City's budget diminishes in places where it does not have to be. When dealing with these persistent problems, the City may find it difficult to effectively and efficiently utilize their resources.

City and State Maintenance Standards

According to studies by the United States Environmental Protection Agency, by the year 2016, the U.S. will have to invest more than ten billion dollars to upgrade existing wastewater collection systems and nearly forty-four billion dollars to improve combined sewer overflows in order to serve our ever-growing population (Hazen and Sawyer). The wastewater collection system does not necessarily have to be broken in order for the City to be required to fix it. The City must spend a portion of its budget funding preventive maintenance operations to pass city and statewide wastewater standards. The two main agencies responsible for setting wastewater collection standards are the Texas Commission on Environmental Quality (TCEQ) and the Environmental Protection Agency (EPA). The TCEQ and the EPA both focus on setting wastewater collection principles that will ensure the quality of human health, protect wildlife, and promote economic advancement (Unit III). Excursions, stoppages, and other disturbances to the collection system can lead to overflows. When the collection system overflows, it releases



Figure 9: Sewer Overflow (275 GPM)

untreated wastewater into the environment and costs the City more money when having to deal with such a problem.

Untreated wastewater can contain anything from harmful chemicals to dangerous bacteria that can cause tuberculosis and

E. coli poisoning. These hazards prove to be a threat, both to public health and wildlife, that the City cannot risk. Faulty construction, aging sewer components, grease, tree roots, and sewer main deterioration are the chief triggers of overflows, and the TCEQ and EPA must develop tactics in order to secure these potential hazards before an overflow can occur. In order to do this, both agencies may enforce compulsory guidelines such as construction requirements to

ensure work quality, mandatory pipe replacement before aging pipes have a chance to leak, and routine sewer cleaning to avoid stoppages due to roots and grease.

Preventive Maintenance Procedures

To stay in compliance with these guidelines, the City makes preventive maintenance one of the responsibilities of the Utilities Maintenance Branch. Although the TCEQ and EPA may propose maintenance requirements on the entire wastewater collection system, this might not always be the most economically efficient strategy for city budgets. In order to be more resourceful, the City will examine their maintenance and repair histories so that they can prioritize their resources based on the necessity in certain areas. This, in turn, will allow the Utilities Maintenance Branch to focus more time and money on areas that need attention the most. To make certain that the collection system operates properly, the City uses section chiefs, inspectors, and supervisors to ensure quality work, performs sewer cleaning for stoppages and all repairs, and implements smoke testing for damaged collection lines. Inflow and Infiltration (I/I) can prove to be a major problem for the TCEQ, EPA, and the wastewater collection system. Inflow and Infiltration happens when leaks or cracks allow storm water or ground water to flow into the wastewater collection system(Mansfieldma). When this occurs, the amount of wastewater that needs to be treated increases, which also causes the rate that the City pays to maintain the collection system to increase. This is why inspectors and supervisors play one of the most crucial roles in preventive maintenance: they make certain that construction is done properly. In doing so, inspectors and supervisors ensure that the City will not have to spend more time and money fixing previous repairs that were not completed properly and also that overflows will not result from improper work. If construction was not the problem and there were reoccurring stoppages in a certain area, the City may then take on a different approach. In the event that stoppages are reported over and over again in the same area, the maintenance

branch will then begin routine sewer cleaning to relieve those problems. If reoccurring problems at a certain property were caused by grease, the City may inform the owner that a grease trap needs to be installed on the collection line to help reduce the number of stoppages and also to pass health inspections(Wesley). If the same situation arises with cracks and open joints, maintenance employees will then use smoke testing to determine if there is an actual problem

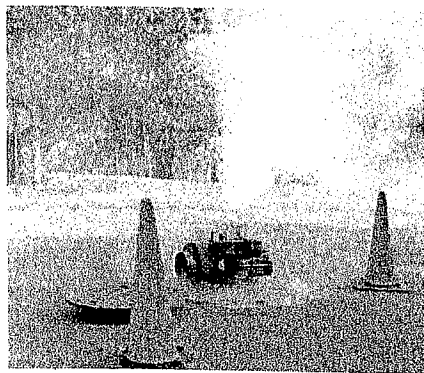


Figure 10: Smoke Testing

and where it is located. Workers will infiltrate the collection line with smoke looking to see if it seeps above the surface. If smoke were somehow released above the surface, it would indicate a crack or open joint in the collection line. By doing this, field workers are informed that there actually is a crack or open joint on

the collection line and that maintenance is definitely required to prevent future hazards. With all of these precautionary procedures in action, it is easy to see that human health and wildlife protection make it essential to implement preventive maintenance.

Preventive Maintenance Expenditures

Even though the City uses its maintenance history to more accurately pinpoint needed repairs, expenditures can still be intimidating. In the 2006 fiscal year, from July 1st, 2005 to June 30th, 2006, the Utilities Maintenance Branch in the City of Houston spent an approximate total of \$4,546,482.70 on sewer repairs. Every time repair teams are sent out into the field, the City must pay for labor wages, supplies, transportation, equipment, and even fuel for all city vehicles. Although funding these necessary resources may seem impossible, the City's focus on high quality work, clear communication and supervision, and meticulous inspections help to decrease wasted time, labor, and equipment.

Overview of Wastewater Collection System

With all of the daily stresses that most people endure, one may never sit and think about why they are able to flush a commode, flip a switch to turn on the garbage disposal, or even pour something down the drain. When a city is operating and maintaining its sewer system as effectively as possible, it may just mean that people will never know the effort it takes to implement the collection and installation process, deal with reoccurring problems and necessary repairs, and keep up with preventive maintenance procedures in accordance with city and state standards. All three of these wastewater collection aspects are equally necessary to successfully maintain an operating wastewater collection system. The wastewater collection system itself would be lost without giving the same effort and devotion to each segment. Even with the City's focus to perfecting each operation, there will always be room for improvement. Out of the abundant number of collection line repairs that the Utilities Maintenance Branch successfully completes, there are some cases where repair crews are sent back to previous jobs in order to make minor adjustments. In the fiscal year of 2006, from July 1st, 2005 to June 30th, 2006, there were a total number of 2,413 sewer repairs. Of these 2,413 total sewer repairs, there were only 59 instances (2.45%) when further work was needed on previous repairs. In order to improve on this minor setback, the Public Works & Engineering Department is attempting to configure its budget in a way to where more inspectors and supervisors can be trained and hired to work with the City within the upcoming years. Instead of inspecting as many jobs as possible, the new city policy should include that *all* jobs done by the City must be inspected before being closed out. By doing this, the City can ensure that high quality work is being performed. This practice in turn will lead to better utilization of workers, materials, and time. Only by accepting the fact that the wastewater collection system still needs improvement can the City of Houston continue to strive for a more efficient and perhaps even perfect wastewater collection system in the future.

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